Dr. MANTELL'S
THOUGHTS ON A PEBBLE

EIGHTH EDITION.

J. A. Osborn

THOUGHTS

ON A

PEBBLE.

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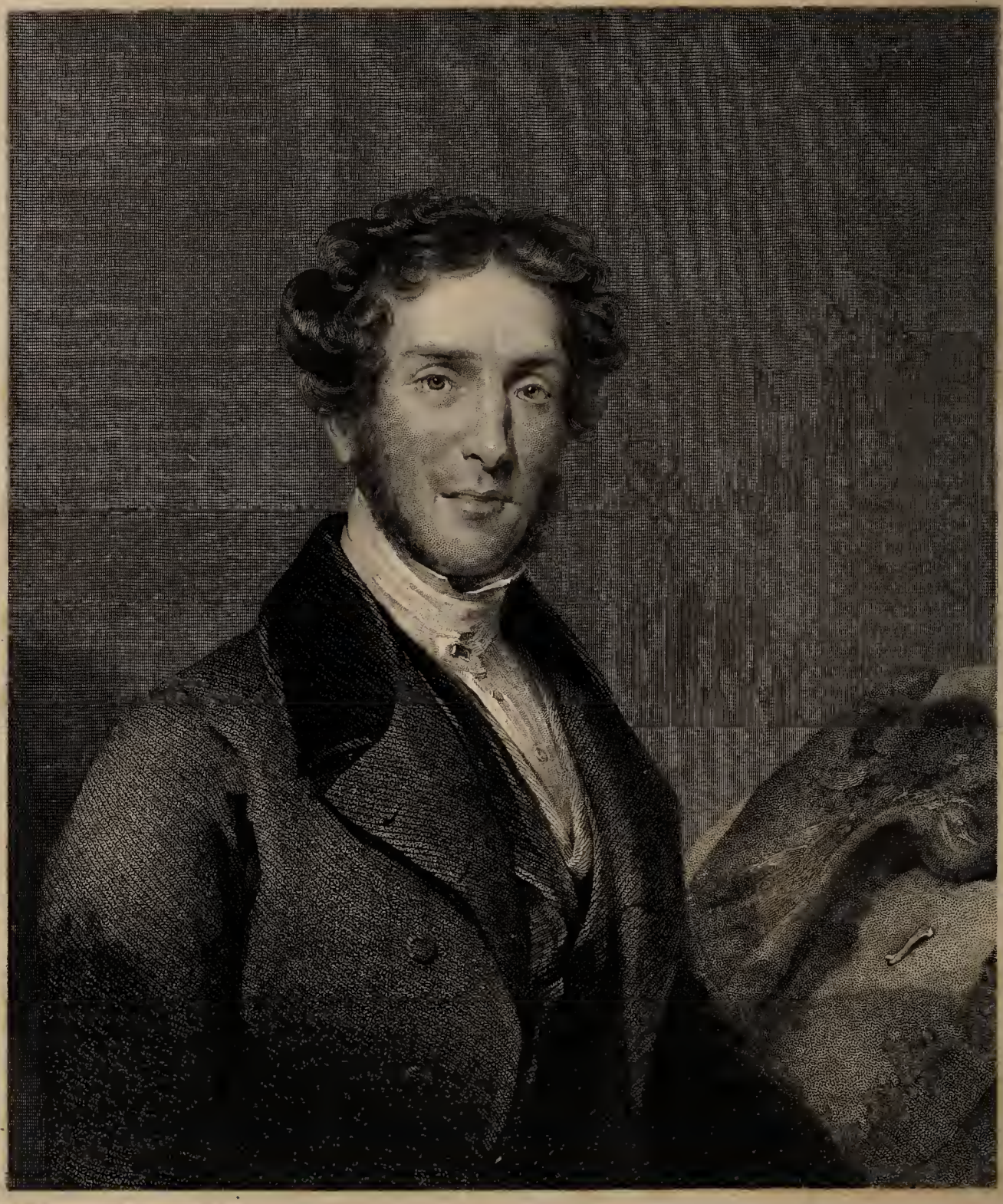

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GIDEON ALGERNON MANTELL, L.L.D. F.R.S.

Vice President of the Geological Society &c. &c.

THOUGHTS

ON A

PEBBLE,

OR,

A FIRST LESSON IN GEOLOGY.

BY THE AUTHOR OF "THE WONDERS OF GEOLOGY."

The Nautilus and the Ammonite. *Vide* p. 57.

"There is no picking up a pebble by the brook-side, without finding all nature in connexion with it."

Contemplations of Nature.

EIGHTH EDITION; WITH THIRTY-TWO ILLUSTRATIONS.

LONDON:

REEVE, BENHAM, AND REEVE, KING WILLIAM STREET, STRAND.

1849.

TO

MY SON,

Reginald Neville Mantell, C.E.,

THESE

"THOUGHTS ON A PEBBLE"

ARE MOST AFFECTIONATELY

INSCRIBED.

LONDON,
19, CHESTER SQUARE, PIMLICO.
1849.

"Every grain of sand is an immensity—every leaf a world—every insect an assemblage of incomprehensible effects in which reflection is lost."

LAVATER.

"To the natural philosopher there is no natural object that is unimportant or trifling. From the least of Nature's works he may learn the greatest lessons. The fall of an apple to the ground may raise his thoughts to the laws which govern the revolutions of the planets in their orbits; or the situation of a *pebble* may afford him evidence of the state of the globe he inhabits, myriads of ages before his species became its denizens."

SIR J. F. W. HERSCHEL.

TO THE READER.

DEEPLY impressed with the conviction that it is of the highest importance the young and inquiring mind should have a correct idea of natural phenomena—that it should not be left to its own unaided efforts to unravel the mysteries of the beautiful world in which this first state of being is destined to be passed—or have its curiosity stifled or misled by unsatisfactory or erroneous conjectures—I have endeavoured in this little work to explain in a simple and attractive guise, some of the grand truths relating to the ancient physical history of our planet, which modern geology has established.

The favourable reception of these dèsultory "*Thoughts,*" which were originally penned for the amusement and

instruction of an intelligent boy, is a gratifying proof that the attempt has not been unsuccessful; and I would fain indulge the hope, that this "*First Lesson in Geology*" may still be productive of good, by exciting in some youthful minds a desire for the acquisition of natural knowledge; and inculcating the important truth, that He who formed the Universe has created nothing in vain; that His works all harmonize to blessings unbounded by the mightiest or most minute of His creatures; and that the more our knowledge is increased, and our powers of observation are enlarged, the more exalted will be our conception of His wondrous works.

Chester Square,
Pimlico.

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THOUGHTS

ON A

PEBBLE.

"Honoured, therefore, be thou, thou small pebble, lying in the lane; and whenever any one looks at thee, may he think of the beautiful and noble world he lives in, and all of which it is capable."

LEIGH HUNT'S *London Journal*, p. 10.

PART I.

WELL might our immortal Shakspeare talk of "*Sermons in stones*;" and Lavater exclaim, that "*Every grain of sand is an immensity*;" and the author of 'Contemplations of Nature' remark, that "*there is no picking up a pebble by the brook-side without finding all nature in connexion with it.*"

I shall confine my remarks to a *flint* pebble, as being the kind of stone familiar to every one. The pebble I hold in my hand was picked up in the bed of the torrent which is dashing down the side of yonder hill, and winding its way through that beautiful valley, and over those

> Huge rocks and mounds confus'dly hurl'd,
> The fragments of an earlier world,

which partially filling up the chasm, and obstructing the course of the rushing waters, give rise to those gentle murmurings that are so inexpressibly soothing and delightful to the soul.

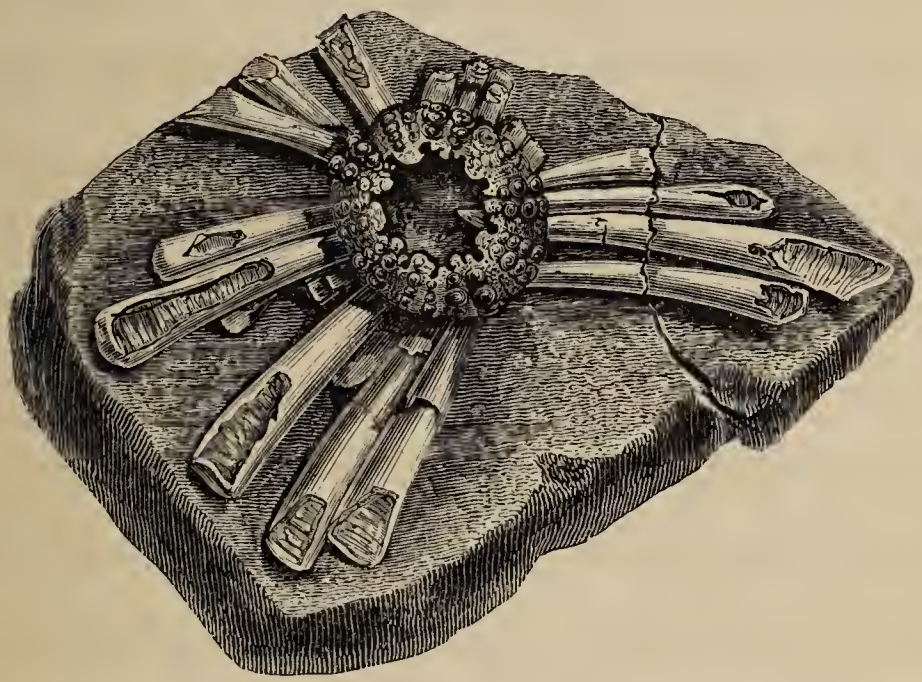
Upon examining this stone I discover that it is but the fragment of a much larger mass, and has evidently been transported from a distance, for its surface is smooth and rounded, the

angles having been worn away by friction against other pebbles, produced by the agency of running water. I trace the stream to its source, half way up the hill, and find that it gushes out from a bed of gravel lying on a stratum of clay, which forms the eminence where I am standing, and is nearly 300 feet above the level of the British Channel. From this accumulation of water-worn materials the pebble must have been removed by the torrent, and carried down to the spot where it first attracted our notice; but we are still very far from having ascertained its origin. The bed of stones on the summit of this hill is clearly but a heap of transported gravel—an ancient sea-beach or shingle—formed of chalk-flints, that at some remote period were detached from their

parent rock, and broken, rolled, and thrown together, by the action of the waves. We are certain of this because we know that flints cannot grow;* that they were originally formed in the hollows or fissures of other stones; and upon

* "*Flints cannot grow.*"—Here I would digress for a moment to notice an opinion so generally prevalent, that perhaps some of my young readers will not be prepared at once to answer the question—*Do stones grow?* The farmer who annually ploughs the same land, and observes a fresh crop of stones every season, will probably reply in the affirmative; and the general observer who has for succcssive years noticed his gardens and plantations strewn with stones, notwithstanding their frequent removal, may possibly entertain the same opinion; but a little reflection will show that stones cannot be said to grow or increase, in the proper acceptation of the term. Animals and plants grow, because they are provided with vessels and organs by which they are capable of taking up particles of matter and converting them into their own substance; but an inorganic body can only increase in bulk by the addition of some extraneous material; hence stones may become incrusted, or they may be cemented together and form a solid conglomerate, but they possess no inherent power by which they can increase either in size or number—*they cannot grow.*

inspecting the pebble more attentively, we perceive, not only that such was the case, but also that it has been moulded in *Chalk*, for it contains



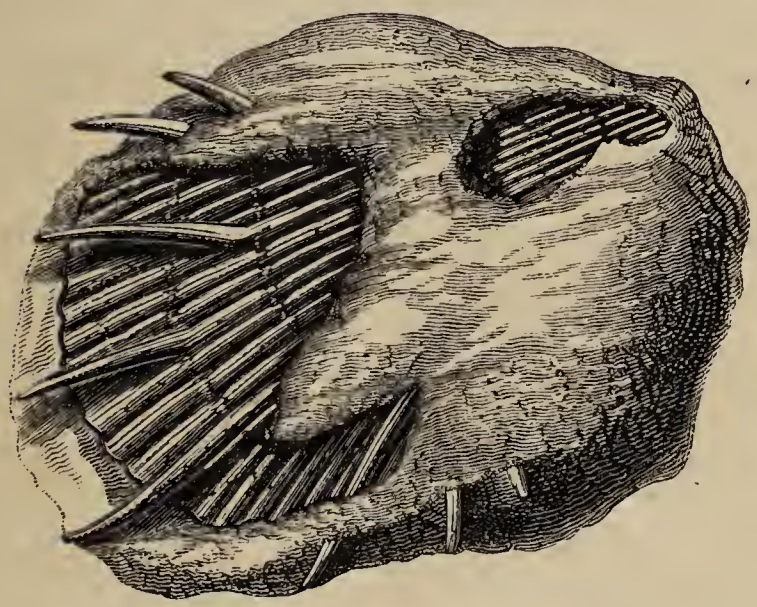
LIGN. 2:—Fossil Turban Echinus, with its spines; in limestone.
(See '*Medals of Creation*,' p. 340.)

the remains of certain species of extinct shells and corals, which are found exclusively in that

rock. Here then a remarkable phenomenon presents itself for our consideration; this flint, now so hard and unyielding, must once have been in a soft or fluid state, for the delicate markings of the case and spine of an *Echinus*, or Sea-Urchin, are deeply impressed on its surface;* and a fragile shell with its spines, is partially imbedded in its substance.† Nay more, upon breaking off one end of the pebble,‡ we find that a sponge, or some analogous marine zoophyte, is entirely enveloped by the flint; and also that there are here and there portions of minute corals, and scales of fishes. What a "*Medal of Creation*" is here—what a page of nature's volume to interpret—what interesting reflections crowd upon the mind!

* Plate 1, *a*. † Plate 1, *b*. ‡ Plate 1, *c*.

To avoid confusion, we will reverse the order of our inquiry, and first contemplate the formation of the flint in its native rock. The Chalk,



LIGN. 3 :—Shell with spines, imbedded in Chalk ; from Lewes.
(See '*Medals of Creation*,' p. 390.)

that beautiful white stone, which (as an American friend, who saw it for the first time, observed), is so like an artificial production, abounds in

marine shells and corals, and in the remains of fishes, crabs, lobsters, and reptiles, all of which differ essentially from living species; although a

LIGN. 4 :—Fossil teeth of Fishes of the Shark family, in Chalk; from Lewes.
(See '*Medals of Creation*,' p. 625.)

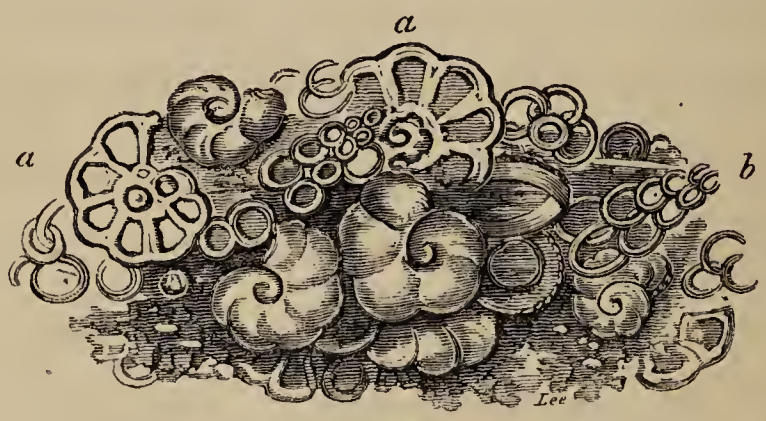
few of the corals and shells resemble, in some particulars, certain kinds that inhabit the seas of

hot climates. These remains are found in so perfect a state—the shells with all their spines and delicate processes (*Lign.* 3), and the fishes with their teeth (*Lign.* 4), scales, and fins, entire—that no doubt can be entertained of the animals having been surrounded by the chalk while living in their native sea, and that many of them were entombed in their stony sepulchres suddenly, when the rock was in the state of mud, or like liquid plaster of Paris.*

But besides the fossils which are obvious to the unassisted eye, the Chalk teems with myriads of minute forms that may readily be detected with a lens of moderate power; and even when these have been extracted, the residue, which

* See Note I. *Shells in the Chalk.*

appears to be merely white calcareous earth, is found, when examined under the microscope, to consist almost wholly of bodies yet more infinitesimal—of perfect shells and corals, so minute,



LIGN. 5:—A few grains of Chalk-dust highly magnified, and shown to consist of shells, &c.

a, *a*, Shells called Rotalia.

b, ———— Textularia.

(See '*Medals of Creation*,' p. 232.)

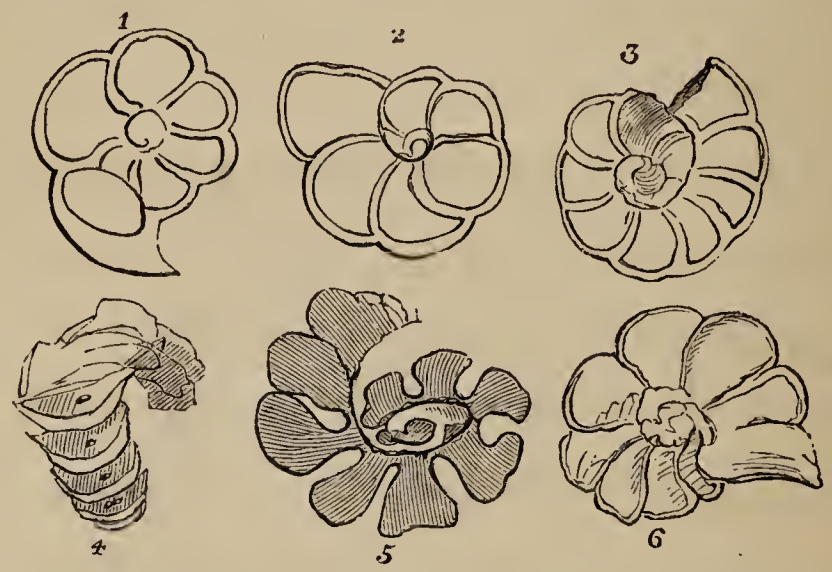
that a cubic inch of chalk may contain upwards of a million of these organic remains (see *Lign.* 5)!

The Chalk is stratified—that is, divided into

strata or layers—as if a certain quantity of mud had sunk to the bottom of the sea, and enveloped the shells, corals, &c., which fell in its way, and had become somewhat solid before another layer was deposited upon it.

The mineral substance termed *silex* or *flint*, is variously distributed in the chalk. It most commonly occurs in the state of nodules of an irregular or spheroidal, globular figure, which are arranged in rows parallel and alternating with, the cretaceous strata; it is likewise disposed in continuous thin layers, which are spread over considerable areas; and it often forms horizontal, vertical, and oblique veins, that fill up the fissures and interstices of the chalk. The siliceous nodules frequently enclose corals, shells, sponges,

and other organic remains, as in the pebble before us; and in many instances these fossils are found partly imbedded in the chalk and partly invested



LIGN. 6:—Minute fossil shells from Flint and Chalk, very highly magnified, and seen by transmitted light.

1, 2, 3, 6, Rotaliæ;
4, Portion of a Nautilus;
5, Rotalia composed of flint.

(See '*Medals of Creation*,' p. 232.)

with flint. But though flints contain in abundance relics of the same species of marine animals

as the chalk, they are not like that rock composed of an aggregation of fossil remains; on the contrary, the siliceous earth, which is their constituent substance, was evidently once in a state of complete solution in water, and precipitated into the chalk before the latter was consolidated, the organic bodies serving as nuclei or centres around which the silex concreted; for the deposition of the flint, like that of the chalk, appears to have taken place periodically.*

The composition of the Chalk, and the prevalence throughout that rock of the relics of animals that can only live in salt-water, prove incontestably that the chalk and flint were deposited in the sea; and that our beautiful South

* Note II. *Wood in flint.*

Downs, now so smooth and verdant, and supporting thousands of flocks and herds, and the rich plains and fertile valleys spread around their flanks, were once the bed of an ocean. It is also evident not only that such must have been the case, but also that the Chalk was deposited in the basin of a very *deep* sea—in the profound abyss of an ocean as vast as the Atlantic.

From the absence of gravel, shingle, and sea-beach, it is certain that the white chalk-strata were formed at a great distance from sea-shores and cliffs; and this inference is confirmed by the swarms of shells termed *Ammonites* and *Nautili*, which we know from their peculiar structure were, like the recent pearly Nautilus, inhabitants of deep waters only. For these are chambered

shells; that is, are divided internally by thin transverse shelly septa or plates, into numerous cells; the body of the animal occupied only the outer compartment, but was connected with the entire series of chambers by a tube or siphuncle, which passed through each partition. This mechanism constituted an apparatus which contributed to the buoyancy of these animals when afloat on the waves; for the Ammonites and Nautili were able to swim on the surface, or sink to the depths of the ocean at pleasure.

The fragile Nautilus that steers his prow,
The sea-born sailor of his shell canoe,
The Ocean Mab, the fairy of the sea,
O'er the blue waves at will to roam is free.
He, when the lightning-winged tornadoes sweep
The surf, is safe, his home is in the deep;

And triumphs o'er the Armadas of mankind,
Which shake the world, yet crumble in the wind.

BYRON, *The Island.*

The Ammonites, so called from the supposed resemblance of their shells to the fabled horn of

LIGN. 7 :—Ammonite from Whitby.

Jupiter Ammon, are only known in a fossil state; but they must have swarmed in the ancient seas, for several hundred species have been discovered in the Chalk and antecedent strata, though none

have been found in any deposits of more recent formation; at the termination of the chalk epoch the whole race, therefore, appears to have perished. The Ammonites are commonly termed *snake-stones*, from the origin ascribed to them by local legends; those of Whitby are well known (see *Lign.* 7).*

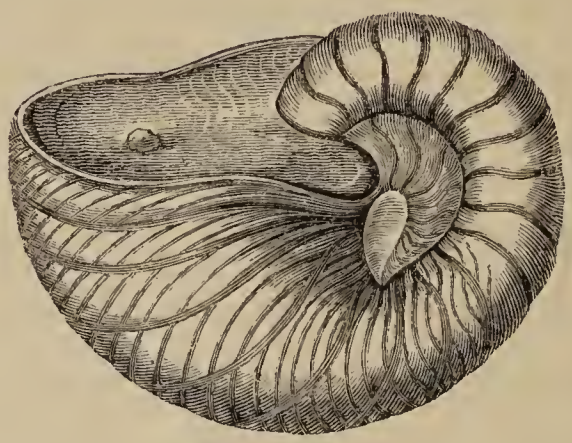
Thus Whitby's nuns exulting told—
How that of thousand snakes, each one
Was changed into a coil of stone,
When holy Hilda prayed:
Themselves, within their sacred bound,
Their stony folds had often found.

SCOTT'S *Marmion.*

The Nautili were the contemporaries of the Ammonites, and many kinds are found associated

* Note III. *Whitby Ammonites.*

with those shells, in strata far more ancient than the Chalk; and several species of both genera, as we have previously shown, were inhabitants of the cretaceous ocean. When the Ammonites be-



LIGN. 8:—Nautilus from the Chalk, near Lewes.
(*one-eighth the natural size.*)

came extinct, the Nautili continued to flourish, and numerous examples occur in the strata that were deposited during the vast period which intervened between the close of the Chalk forma-

tion, and the dawn of the existing condition of the earth's surface. At the present time two or three kinds only are known in a living state, and these are restricted to the seas of tropical climes, and so seldom approach the shores, that but few specimens of the animals that inhabit the shells have been obtained.

The Nautilus, therefore, is one of those types of animal organization that have survived all the physical revolutions to which the surface of the earth was subjected during the innumerable ages that preceded the creation of the human race.* This remarkable fact is portrayed with much force and beauty by Mrs. Howitt, in the following stanzas:

* Note IV. *Fossil Nautili.*

TO THE NAUTILUS.

Thou didst laugh at sun and breeze
In the new created seas;
Thou wast with the reptile broods
In the old sea solitudes,
Sailing in the new-made light,
With the curled-up Ammonite.
Thou surviv'dst the awful shock,
Which turn'd the ocean-bed to rock;
And chang'd its myriad living swarms
To the marble's veined forms.
Thou wert there, thy little boat,
Airy voyager! kept afloat,
O'er the waters wild and dismal,
O'er the yawning gulfs abysmal;
Amid wreck and overturning,
Rock-imbedding, heaving, burning,
Mid the tumult and the stir,
Thou, most ancient mariner!
In that pearly boat of thine,
Sail'dst upon the troubled brine.

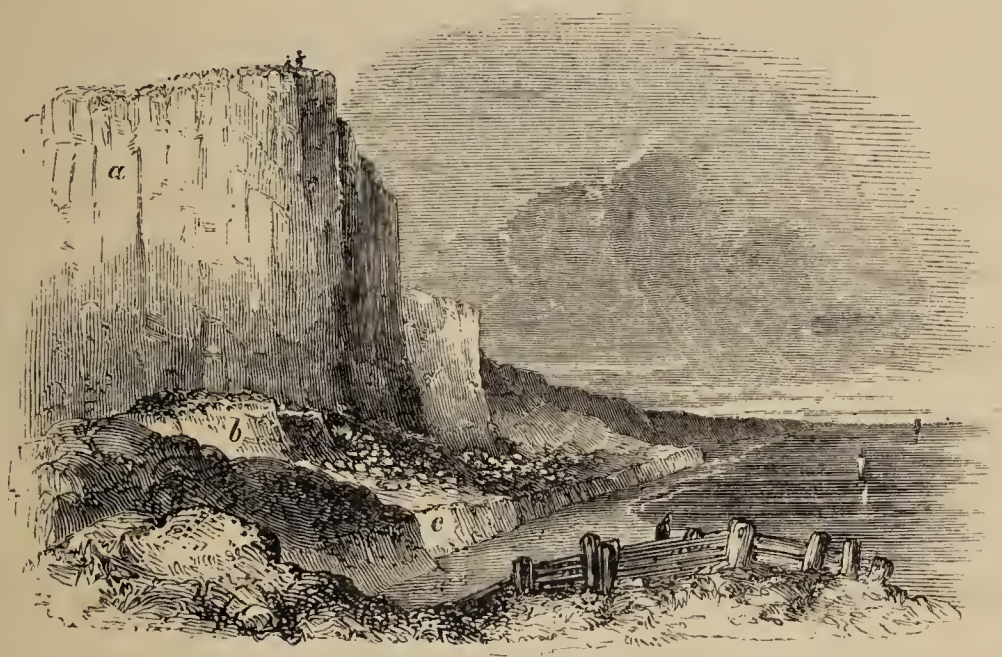
We have thus acquired satisfactory proof that the flint of which our pebble is composed, was once fluid in an ocean teeming with beings, of genera and species unknown in a living state, and that it consolidated and became imbedded in the chalk, which was then being deposited at the bottom of the sea; hence the shells, corals, and other organic remains, which we now find attached to its surface, and enclosed in its substance. Thus much for the origin of the pebble; let us next inquire by what means it was dislodged from its rocky sepulchre, cast up from the depths of the ocean, and transported to the summit of the hill whence it was dislodged by yonder torrent. If we stroll along the sea-shore, and observe the changes which are there going

on, we shall obtain an answer to these questions; for

> There is a *language* by the lonely shore—
> There is society where none intrudes,
> By the deep Sea, and music in its roar!
>
> BYRON.

The incessant dashing of the waves against the base of the chalk-cliffs, undermines the strata, and huge masses of rock are constantly giving way and falling into the waters. The chalk then becomes softened and disintegrated, and is quickly reduced to the state of mud, and transported to the tranquil depths of the ocean, where it subsides and forms new deposits; but the flints thus detached, are broken and rolled by attrition into the state of boulders, pebbles, and gravel, and ultimately of sand.

Now we must bear in mind, that had the chalk remained at the bottom of the deep sea in which it was originally deposited, it would not



LIGN. 9 :—View of Brighton Cliffs; looking eastward from Kemp Town.*
a. Cliffs composed of chalk rubble.
b. Ancient elevated sea-beach.
c. Chalk forming the base of the Cliffs.

have been exposed to these destructive operations. It is therefore manifest, that at some very dis-

* Note V. *Brighton Cliffs.*

tant period of the earth's physical history, the bed of the Chalk-ocean was broken up, extensive areas were protruded above the waters, lines of sea-cliffs were formed, and boulders, sand, and shingle accumulated at their base. Subsequent elevations of the land took place, and finally, the sea-beach was raised to its present situation, which is several hundred feet above the level of the sea!

Every part of the earth's surface presents unequivocal proofs that the elevation of the bed of the ocean in some places, and the subsidence of the dry land in others, have been, and are still, going on; and that, in truth, the continual changes in the relative position of the land and water, are the effects of laws which the

Divine Author of the Universe has impressed on matter, and thus rendered it capable of perpetual renovation :—

Art, Empire, Earth itself, to change are doomed ;
Earthquakes have raised to heaven the humble vale,
And gulfs the mountain's mighty mass entombed,
And where the Atlantic rolls wide continents have bloomed.

BEATTIE.

Our noble poet, Lord Byron, in his sublime apostrophe to the Sea, has most eloquently enunciated the startling fact revealed by modern geological researches,—namely, that if the character of immutability be attributable to anything on the surface of our planet, it is to the ocean and not to the land !—

Roll on, thou deep and dark blue ocean—roll !
Ten thousand fleets sweep over thee in vain ;

Man marks the earth with ruin—his controul
Stops with the shore:—upon the watery plain
The wrecks are all thy deed, nor doth remain
A shadow of man's ravage, save his own,
When, for a moment, like a drop of rain,
He sinks into thy depths with bubbling groan,
Without a grave, unknell'd, uncoffin'd, and unknown!

Thy shores are empires, changed in all save thee,—
Assyria, Greece, Rome, Carthage, what are they?
Thy waters wasted them while they were free,
And many a tyrant since; their shores obey
The stranger, slave, or savage,—their decay
Has dried up realms to deserts:—not so thou,
Unchangeable, save to thy wild waves' play—
Time writes no wrinkle on thine azure brow:
Such as Creation's dawn beheld, thou rollest now!

Thou glorious mirror, where the Almighty's form
Glasses itself in tempests; in all time,

Calm or convulsed—in breeze, or gale, or storm,
Icing the Pole, or in the torrid clime
Dark-heaving, boundless, endless, and sublime—
The image of Eternity—the throne
Of the Invisible; even from out thy slime
The monsters of the deep are made; each zone
Obeys thee: thou goest forth, dread, fathomless, alone!

CHILDE HAROLD. *Canto IV.*

I will conclude this "first lesson" with the following beautiful remark of an eminent living philosopher:*—"To discover order and intelligence, in scenes of apparent wildness and confusion, is the pleasing task of the geological inquirer; who recognises, in the changes which are continually taking place on the surface of the globe, a series of necessary operations, by which

Dr. Paris.

the harmony, beauty, and integrity of the Universe are maintained and perpetuated; and which must be regarded, not as symptoms of frailty or decay, but as wise provisions of the Supreme Cause, to ensure that circle of changes, so essential to animal and vegetable existence."

MORE THOUGHTS

ON A

P E B B L E.

"Not a mote in the beam, not an herb on the mountain, not a pebble on the shore, not a seed far-blown into the wilderness, but contributes to the lore that seeks in all the true principle of life—the beautiful—the joyous—the immortal."

Sir E. Bulwer Lytton's *Zanoni.*

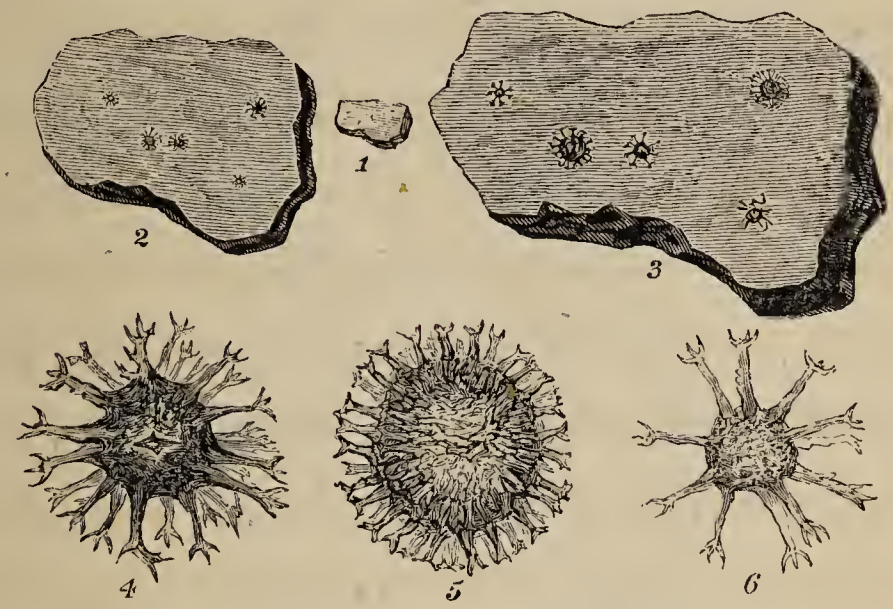
PART II.

More thoughts on a pebble!—is not the subject exhausted? have not all the hieroglyphics impressed on the flint been interpreted?—can Science, like the fabled wand of the magician, call forth from the stone and from the rock their hidden lore, and reveal the secrets they have

so long enshrined?—Gentle Reader! but one page of the eventful history of the pebble has been deciphered; I proceed to transcribe this natural record of the past, explain its mysterious characters, and present to thy notice the marvels they disclose.

Our previous examination of the specimen showed that the flint had once been in a fluid state, and had consolidated in a sea inhabited by shells, echini, fishes, corals, sponges, and other zoophytes; and the appearance of the fractured end (*Plate* 1, *c*), indicated that some organic body had formed the nucleus of the pebble, and that traces of the structure of the original still remained. To ascertain if this inference is correct, it will be necessary to divide the stone

in a longitudinal direction—but I will first strike off a small fragment, and examine it by the aid of a microscope.

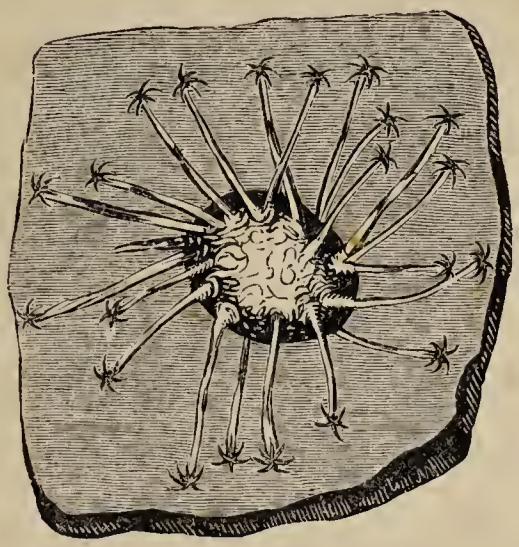


LIGN. 10 :—Fossil animalcules (*Xanthidia*) in Flint.

By a sharp blow of a hammer, a very thin and minute portion of the flint has been detached (see *Lign.* 10, *fig.* 1); it is translucent, and when held between the eye and a strong light, appears

like a slice of horn; and a few extremely minute specks may with difficulty be detected. Under the microscope, five of these almost invisible points are well defined, and present a radiated appearance (see *fig.* 3); but I will substitute a higher power, and lo! they are seen to be distinct globular or spherical bodies beset with spines (*fig.* 3); and with a still more powerful lens, one which magnifies many hundred times, their nature is completely displayed. The whole five possess this general character—a central globular case or shell, from which radiate tubes or hollow spines, that terminate in fringed or divided extremities (*figs.* 4, 5, 6); but these bodies differ from each other in the relative proportions of the shell and spines, and in

the number, shape, and length of the tubular appendages. The group, in short, is separable into three distinct species, of the same kind of fossil remains; and several other varieties occur in the chalk and flint.



LIGN. 11 :—*Xanthidium palmatum* in flint: highly magnified.

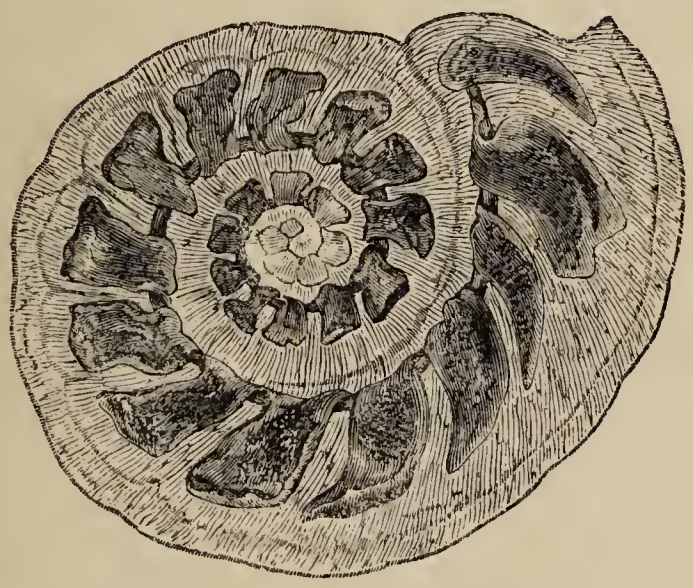
But what are these bodies?—They are the durable cases of animalcules, many species of

which swarm in our seas, and are so minute, that thousands may be contained in a drop of water! In a living state, the case is flexible and filled with a granular jelly, which is the soft body of the animalcule, and the tubes and the outer surface are invested with a similar substance. After death the soft parts dissolve; but the case and its spines often remain unchanged.

In another magnified portion of the pebble, a specimen of the microscopic discoidal shells which we have already seen compose the greater part of the white chalk (*Lign.* 5, p. 14), is beautifully displayed when viewed by transmitted light, under a highly magnifying power (*Lign.* 12).* Our investigation has thus shown, that a great part

* Note VI. *Rotaliæ in chalk and flint.*

of the pebble is actually composed of the aggregated fossil remains of animalcules, so minute as to elude our unassisted vision, but which the magic power of the microscope reveals to us, pre-

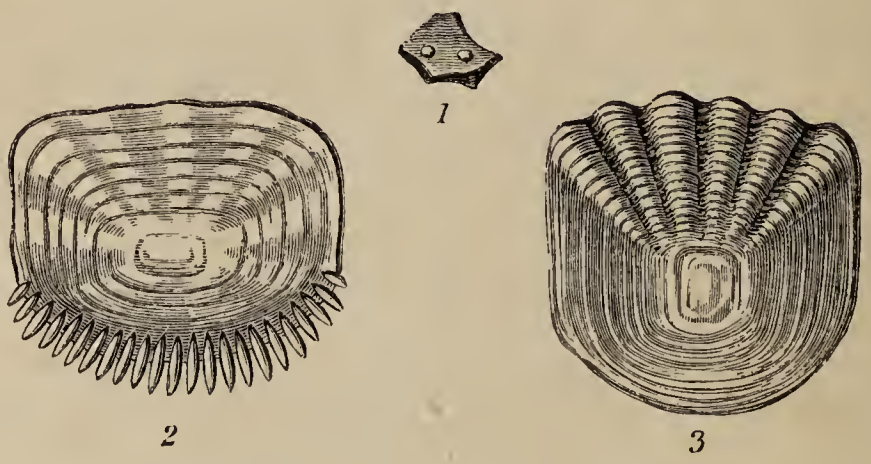


LIGN. 12 :—Rotalia in flint : highly magnified.

served, like flies in amber, in all their original sharpness of outline and delicacy of structure.

On another fragment of this stone two

glittering specks, not larger than a pin's head, are discernible (*Lign.* 9): these with a magnifier of moderate power, are seen at a glance to be scales of fishes. But they differ from each other;



LIGN. 13:—SCALES OF FISHES in flint.

Fig. 1.—A fragment of the pebble with the scales of the natural size.
2.—One of the Scales (of a species of *Beryx*) highly magnified.
3.—The other Scale (of a species of *Salmo*).

both have the surface smooth, and without enamel: in the one the margin or edge is simple (*fig.* 3); in the other, it is divided like the teeth of

C

Longitudinal section of the Pebble.

Page 41.

a comb (fig. 2);—trifling as this difference may appear, it is sufficient to enable the naturalist to determine that the fishes which furnished these scales belonged to two distinct orders, of which the Salmon and the Mullet are living examples.

SECTION OF THE PEBBLE.

Plate 2.

We will now avail ourselves of the assistance of the lapidary, and divide the pebble in a longitudinal direction;—what a beautiful and interesting section is thus obtained! The markings observable on the fractured portion of the stone (see *Plate* 1, *c*), are thus shown to have originated, as we surmised, from some organic body,

which the flint, when fluid, had penetrated and enveloped. The enclosed fossil was obviously one of those soft marine zoophytes, allied to the *Actiniæ* or *Sea-Anemones*, which are of a globular, spherical, or inversely conical shape, and consist of a tough, jelly-like substance, permeated with tubes, disposed in a radiated manner around a central cavity, or digestive sac; a structure admitting of that constant supply and circulation of sea-water, which the economy of these curious forms of animal existence requires.

The surface exposed by the division of the pebble, is an oblique vertical section of the petrified zoophyte. It shows a central canal filled with bluish-grey flint (*Plate* 2, *c*), in a mass traversed by tubes or channels, which possess

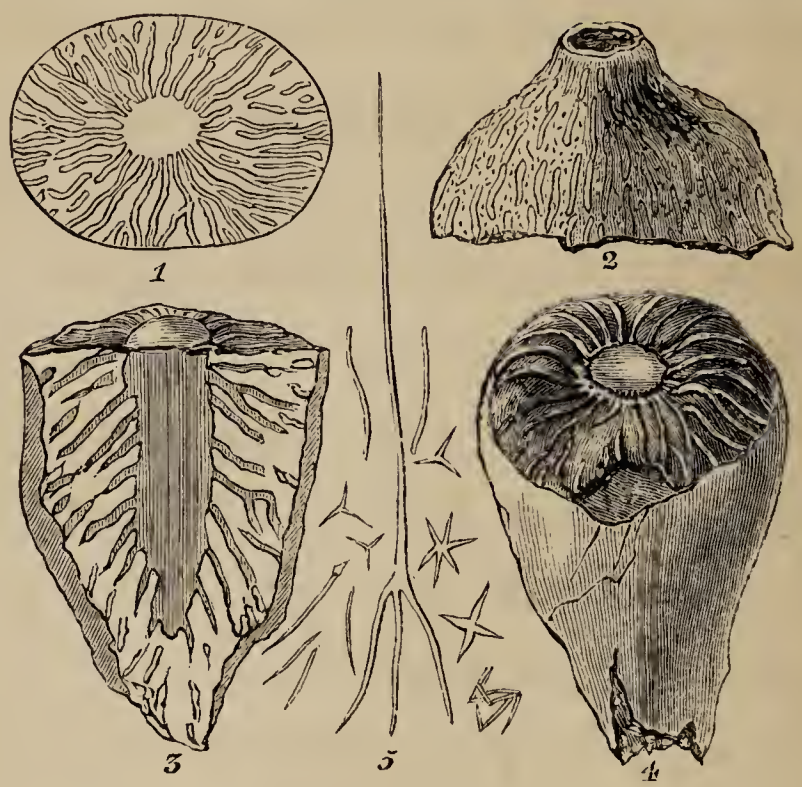
considerable beauty and variety of colour from an impregnation of iron.* A transverse section (see *Lign.* 14. fig. 1) would, of course, have a central spot, with rays proceeding thence to the circumference, as in the oblique fracture (*Plate* 1, *c*).†

The form of the original zoophyte when living, must have been that of an inverted cone or funnel, (hence the scientific name *Choanite* or funnel-like,) with a long cylindrical digestive cavity in the centre, from which tubes ramified through

* Specimens of this kind form beautiful objects when polished, and are mounted as brooches by the lapidaries of Brighton, Bognor, and the Isle of Wight, who term them petrified sea-animal flowers. Mr. G. Fowlstone (4, Victoria Arcade) of Ryde, has many splendid examples, and also agates and jaspers, the *genuine* productions of the Island.

† Note VII. *Isle of Wight Pebbles.*

every part of the mass. It was attached to a



LIGN. 14:—CHOANITES *Konigi*: from the CHALK.

Fig. 1.—A transverse section.
2.—Upper portion of the body.
3.—Vertical section, like the pebble, Pl. II. p. 41.
4.—A flint, enclosing a Choanite, which is exposed on the upper surface.
5.—Various forms of siliceous spines of Choanites and other analogous bodies; magnified slightly.

(See '*Medals of Creation*,' p. 264.)

rock, stone, or shell, by root-like fibres which

spread out from its base; and its soft body was strengthened, as is the case in many sponges and animals of a similar nature, by numerous siliceous spines or spicula, which are often found in the flint and chalk (see *Lign.* 10. fig. 5).*

The *Choanites* must have swarmed in the Chalk ocean, for in some of the strata almost every flint exhibits traces of these zoophytes.†

One more character inscribed on the pebble remains to be interpreted; it is the minute

* Note VIII. *Zoophytes of the Chalk.*

† The shingle at Brighton and Bognor in Sussex, and in various localities in the Isle of Wight, abounds in specimens more or less perfect. I would inform my fair readers who may visit these places, and be inclined to purchase a brooch, in illustration of these "*Thoughts on a Pebble*," that by far the greater number of the so-called Brighton and Isle of Wight moss-agates, jaspers, &c., sold by the lapidaries and jewellers, are of German or Scotch origin; and that the *false-emeralds*, and *aqua-marines*, are water-worn fragments of common green glass bottles!

branch of coral partially imbedded in the flint.* The surface of this coral, when seen with a powerful lens, is found to be studded with small pores or cells. In a recent state, each cell was in-

LIGN. 15 :—Branch of CORAL on the Pebble.
Fig. 1.—A portion magnified.
2.—A fragment represented as when alive.
a, *a*, Two polypes collapsed.
b, *b*, Two polypes with their tentacula extended.

habited by a living polype or animalcule, which, though permanently united at its base to the

* Plate 1. immediately below the shell and spine of Echinus.

general mass, had an independent existence, and possessed sensation and voluntary motion; expanding its thread-like feelers or tentacula to

LIGN. 16 :—A Coral-polype preserved in flint: magnified 500 diameters.

catch its prey, and withdrawing, at will, into its little cell.*

* For a popular account of recent and fossil corals, see 'Wonders of Geology,' 6th Edit., vol. ii. Lecture VI. p. 589.

From these investigations, we learn that the Pebble, which has formed the subject of our contemplation, had its origin in a living zoophyte that was growing on a rock, in a sea whose boundaries have long since been swept away; that corals, shells, and echini inhabited the bottom of the deep; and that fishes related to existing families, sported in the waters of that ancient ocean. In fine, we have presented to us the scene so exquisitely described by the American poet:—

THE CORAL GROVE.

Deep in the waves is a coral grove,
Where the purple mullet and gold fish rove,
Where the sea-flower spreads its leaves of blue,
That never are wet with the falling dew,

But in bright and changeful beauty shine,
Far down in the green and glassy brine.
The floor is of sand, like the mountain drift,
And the pearl-shells spangle the flinty snow;
From coral rocks the sea-plants lift
Their boughs, where the tides and billows flow;
The water is calm and still below,
For the winds and the waves are absent there,
And the sands are bright as the stars that glow
In the motionless fields of upper air:
There with its waving blade of green,
The sea-flag waves through the silent water,
And the crimson leaf of the dulse is seen,
To blush like a banner bathed in slaughter.
There with a light and easy motion
The fan-coral sweeps through the clear deep sea;
And the yellow and scarlet tufts of ocean,
Are bending like corn on the upland lea;
And life in rare and beautiful forms,
Is sporting amidst those bowers of stone.

PERCIVAL.

Our previous examination of the pebble had prepared us for these results; but the micro-

LIGN. 17 :—Minute Corals from the Chalk ;* *highly magnified.*

scope, that mighty talisman of wisdom, has shown us, that even those infinitesimal creatures

* Note IX. *Minute corals from the Chalk.*

to whom a drop of water is an unbounded ocean —those living atoms of that world of being which is for ever concealed from the uninstructed mind —the inhabitants of that universe beneath us, which the eye of science can alone penetrate, existed in ages incalculably remote, and were, like their gigantic contemporaries, the living instruments by which a large proportion of the solid materials of the surface of our planet was elaborated; their imperishable siliceous and calcareous skeletons, constituting no inconsiderable amount of the crust of the earth.*

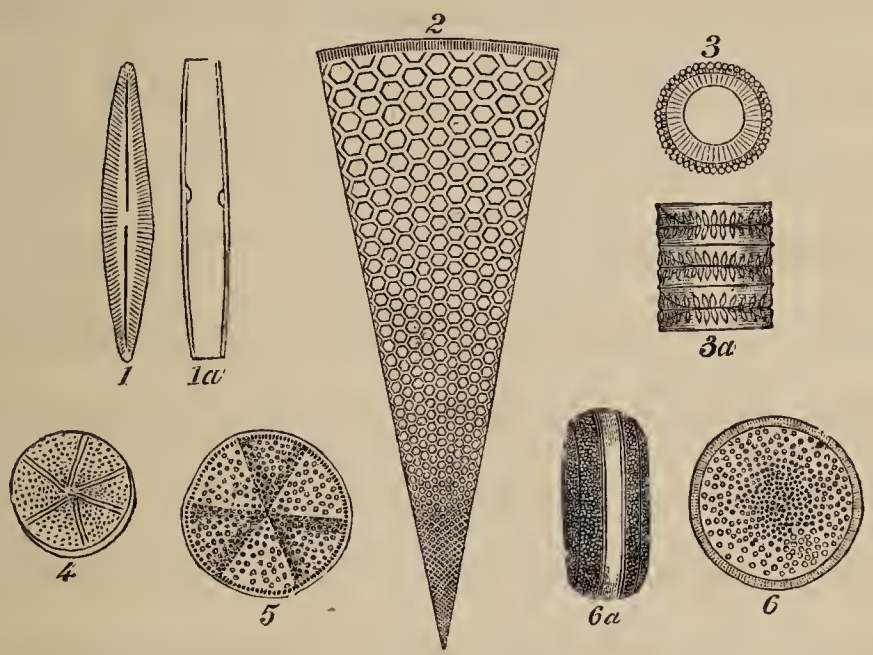
Fossil animalcules and corals similar to those

* See "*Thoughts on Animalcules, or a Glimpse of the Invisible World revealed by the Microscope,*" by the Author. Published by Mr. Murray, London, 1846.

we have discovered in the pebble and in the chalk, and hundreds of other genera and species equally minute, occur in such prodigious numbers, as to warrant the conclusion, that this class of animal existence has contributed more largely than any other, to the formation of the sedimentary strata.

Not only the Chalk hills, but whole mountain-ranges formed of other deposits of great thickness and extent, are found to consist almost entirely of similar remains. In the state of rock, of sand, of clay, of marl—in the coarsest limestone, and in the purest crystal, the petrified skeletons of animalcules alike abound. The town of Richmond, in Virginia, is built on a bed of stone twenty feet thick, which is wholly composed of the fossil

skeletons of different kinds of marine animalcules. The polishing slate of Bilin, in Germany, is wholly made up of the siliceous shields of



LIGN. 18 :—Animalcules from the Richmond earth : very highly magnified.*

similar beings, disposed in layers without any connecting medium; and these belong to species

* Note IX. *Richmond Infusorial earth.*

so minute, and are so closely compressed together, that in a cubic inch of the stone, weighing but two hundred and twenty grains, there are the remains of *forty-one thousand millions* of animalcules! *

Here we must bring our "*Thoughts on a Pebble*" to a close; but not without adverting to the pure and elevating gratification which investigations of this nature afford, and the beneficial influence they exert upon the mind and character. In circumstances where the uninstructed and incurious eye can perceive neither novelty nor beauty, he who is imbued with a taste for natural science will everywhere discover

* See '*Medals of Creation*,' p. 221.

an inexhaustible mine of pleasure and instruction, and new and stupendous proofs of the power and goodness of the Eternal! For every rock in the desert, every boulder on the plain, every pebble by the brook-side, every grain of sand on the sea-shore, is fraught with lessons of wisdom to the mind which is fitted to receive and comprehend their sublime import.

"From millions take thy choice,
In all that lives a guide to God is given;
Ever thou hear'st some guardian angel's voice,
When nature speaks of heaven!"

Amidst the turmoil of the world and the dreary intercourse of common life, we possess in these pursuits a never-failing source of delight, of which nothing can deprive us—an oasis in the desert, to which we may escape, and find a home

"wherever the intellect can pierce, and the spirit can breathe the air." * For like the plant which the Prophet threw into the waters of Marah,† that changed the bitterness of the wave into sweetness, a branch from the tree of knowledge thrown into the turbid stream of life, purifies its waters, and imparts to them a healing virtue, which sheds a hallowing and refreshing influence over the soul!

* Sir E. Bulwer Lytton. † Exod. xv. 23.

THE NAUTILUS AND THE AMMONITE.

(*See Page* 22.)

FROM SKETCHES IN PROSE AND VERSE,

BY THE LATE G. F. RICHARDSON, ESQ.

THE Nautilus and the Ammonite
Were launch'd in storm and strife;
Each sent to float, in its tiny boat,
On the wide, wild sea of life.

And each could swim on the ocean's brim,
And anon, its sails could furl;
And sink to sleep in the great sea deep,
In a palace all of pearl.

And their's was a bliss, more fair than this,
That we feel in our colder time;
For they were rife in a tropic life,
In a brighter, happier clime.

They swam 'mid isles, whose summer smiles
No wintry winds annoy;
Whose groves were palm, whose air was balm,
Where life was only joy.

They roam'd all day, through creek and bay,
And travers'd the ocean deep;
And at night they sank on a coral bank,
In its fairy bowers to sleep.

And the monsters vast, of ages past,
They beheld in their ocean caves;
And saw them ride, in their power and pride,
And sink in their billowy graves.

Thus hand in hand, from strand to strand,
They sail'd in mirth and glee;
Those fairy shells, with their crystal cells,
Twin creatures of the sea.

But they came at last, to a sea long past,
And as they reach'd its shore,
The Almighty's breath spake out in death,
And the Ammonite liv'd no more.

And the Nautilus now, in its shelly prow,
As o'er the deep it strays,
Still seems to seek, in bay and creek,
Its companion of other days.

And thus do we, in life's stormy sea,
As we roam from shore to shore;
While tempest-tost, seek the lov'd—the lost—
But find them on earth no more!

Geology, in the magnitude and sublimity of the objects of which it treats, ranks next to Astronomy in the scale of the sciences.

Sir J. F. W. Herschel.

SUPPLEMENTARY NOTES.

Note I. Page 13. *Shells in Chalk.*

The shells of mollusca, in consequence of their durability, are the most abundant fossils in the sedimentary strata ;* entire layers of marble and other limestone, of great thickness and extent, are wholly composed of an aggregation of a few species or genera : in some instances of fresh-water snails—as, for example, the Sussex and Purbeck marbles ;† in others, of marine bivalves and univalves, as the oyster-conglomerate of Bromley, and the shelly limestones of Portland, Dorsetshire, &c.

The cretaceous strata contain many hundred species of bivalves and univalves, by far the greater part of which

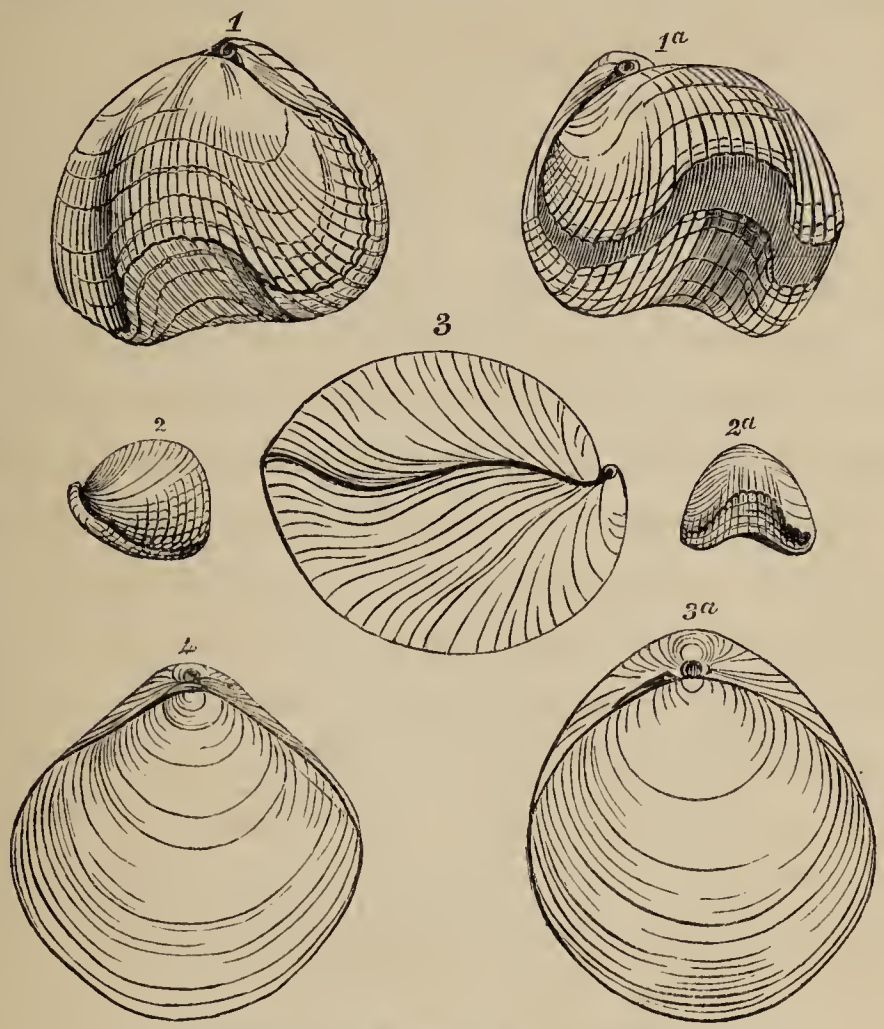
* For an account of the geological value of fossil shells, see '*Medals of Creation*,' vol. i. p. 363.

† See '*Wonders of Geology*,' 6th Edition, p. 402.

belong to extinct genera; and the species, with but four or five exceptions, are unknown in more recent deposits. In loose sandy strata, fossil shells are oftentimes beautifully preserved, and may be obtained in as perfect a condition as if gathered from the sands on the sea-shores: such is the state of the specimens which abound in the sandy clays near Barton in Hampshire, and in the "*Crag*" of Essex and Suffolk. In certain beds of clay, shells are also found entire; sometimes retaining the epidermis, and the cartilaginous ligament of the hinge. The bivalves in the white chalk are generally perfect; but the univalves, probably from the more delicate structure of the originals, seldom retain any vestiges of the shell, excepting portions of the internal nacreous coat adhering to the chalk casts, which have been moulded in the interior of the shells.

In some of the cretaceous strata several extinct species of *Oyster, Scallop, Arca, Tellina,* and other well-known marine bivalves abound; and with them are associated many genera of which no living species have been observed. Among the bivalves that prevail in the English

chalk, are three or four kinds of *Terebratulæ*: which are



LIGN. 19:—Bivalve shells (*Terebratulæ*) from Chalk (*natural size*).
1, 2. Plicated species. 1. *T. octoplicata.* 2. *T. subplicata.*
3, 4. Smooth species. 3. *T. semiglobosa.* 4. *T. subrotunda.*

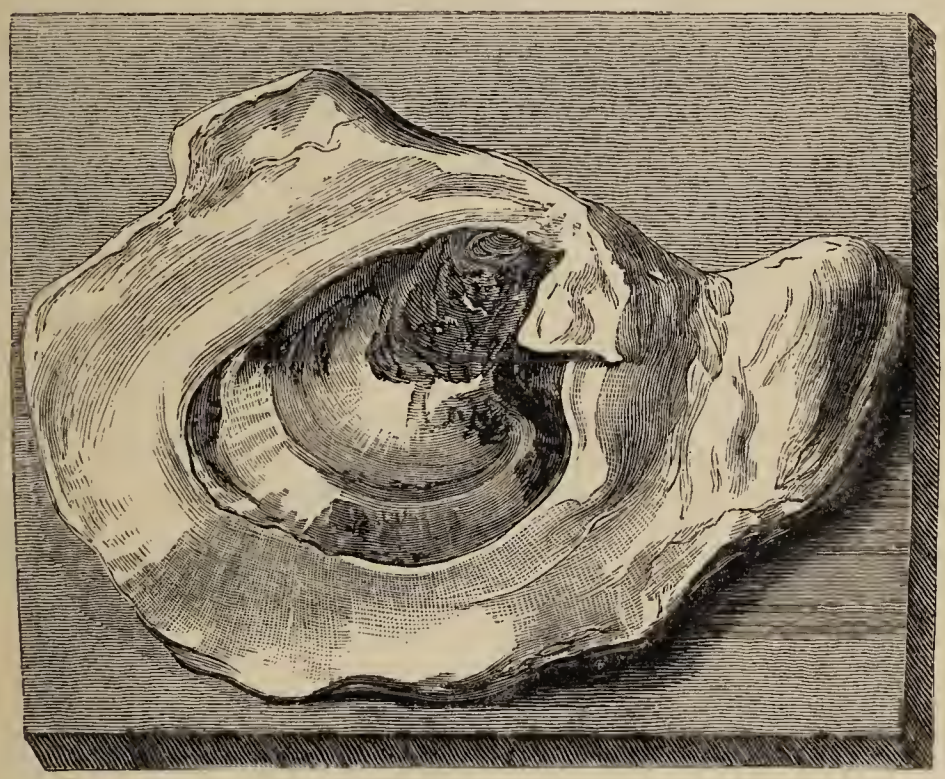
small, elegant, subglobular shells, belonging to a family

of which nearly 500 species, referable to several genera, have been obtained from the British strata.* Certain genera are restricted to the most ancient sedimentary rocks, in which they occur in almost incredible numbers; others have a wider range and are met with in the later secondary deposits; while a few are found in the newest beds, and have living representative species in the seas of warm climates. From the immense antiquity of their lineage, these *Terebratulæ* have been humourously termed the *"fossil aristocracy."* Some of the most common chalk species are figured of the natural size in *Lign.* 19. When living the animal was attached to a rock or other body by means of a *byssus* or peduncle, exserted through the aperture in the beak or curved extremity of the largest valve.† The shells of the smooth *Terebratulæ* are full of minute holes or perforations, which may readily be distinguished with a lens of moderate power.

* See '*Wonders of Geology*,' 6th Edit. p. 329.

† In the Conchological Gallery of the British Museum there is a group of thirty or forty recent *Terebratulæ* attached to a stone by their peduncles; from Australia.

Occasionally the soft body of the mollusk completely silicified—that is, transmuted into flint—is found in its natural position in the shell. A beautiful example of



LIGN. 20 :—Oyster from the Chalk, near Brighton (*natural size*).

this kind is represented in *Lign.* 20. It is an extinct species of oyster: both valves were entire when I re-

moved the chalk and cleared the specimen; part of one valve has been broken away to expose the petrified body of the animal. I have seen a *Trigonia* * from the oolite of Tisbury in Wiltshire, in which the entire body of the mollusk was transformed into flint, and the *branchiæ* or lamellated gills were beautifully defined, though converted into semi-transparent chalcedony.

Note II. Page 17. *Wood in Flint.*

I would remind the reader that the white chalk, together with the various strata of sand, clay, and limestone, comprising the cretaceous formation of England, must be regarded as an ancient ocean-bed; in other words, an accumulation of earthy sediments, formed in the profound depths of the sea, in periods of long duration and of incalculable antiquity, and more or less consolidated

* *Trigonia:* a genus of bivalves, of which there are many extinct species in the chalk and oolite; some bands of Portland stone are an aggregation of *Trigoniæ:* a few very small species, inhabitants of the seas of Australia and New Zealand, are the only known living forms of this once prevailing type of mollusca. See '*Medals of Creation*,' p. 407.

by subsequent chemical and mechanical agency. These deposits are made up of organic and inorganic materials: the former consist of the debris of the cliffs and shores which encompassed the ancient ocean, of the spoils of the land brought into the waters by floods and rivers, and of mineral matter thrown down from chemical solutions. The organic substances are the durable remains of the animals and plants which lived and died in the sea, and of terrestrial and fluviatile species that were transported from islands or continents by rivers and their tributaries. The whole constitutes such an assemblage of strata as would probably be presented to observation, if a mass of the bed of the Atlantic 2,000 feet in thickness, were elevated above the waters, and became dry land; the only essential difference would be in the generic and specific characters of the imbedded animal and vegetable remains.

The vestiges of terrestrial and fluviatile animals and plants found in the chalk are comparatively but few: I have collected from Kent and Sussex, bones of gigantic land lizards, (the *Iguanodon*), of flying reptiles, (*Pterodactyles*), and of fresh-water Turtles, and water-worn frag-

ments of stems of coniferous trees allied to the *Araucaria* or Norfolk Island Pine; fruits or aments of coniferæ; and stems and foliage of plants related to the *Cycas* and *Zamia*.

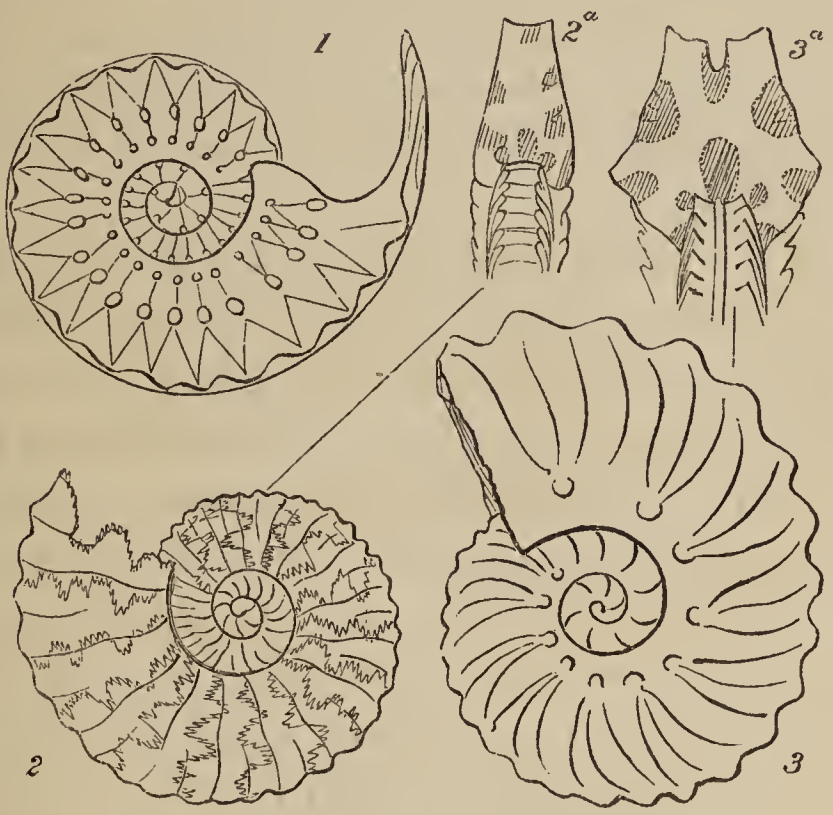
A fragment of silicified wood imbedded in a flint, is

LIGN. 21:—Fragment of coniferous wood in Flint.

represented in *Lign.* 21. It was obtained from a wall in Lewes Priory in Sussex; and though it has been exposed to the atmosphere seven or eight centuries, still exhibits the characteristic internal structure.

Note III. Page 20. *Whitby Ammonites.*

The Ammonites differ from the Nautili in having the



LIGN. 22:—Ammonites from the cretaceous formation.

1. *Ammonites varians*, from Hamsey.
2. *A. Dufresnoyi:* 2 *a*, part of the same.
3. *A. lautus:* 3 *a*, keel and septum of the same.

margins of the septa or internal shelly partitions (which

in the latter are smooth), foliated or wrinkled; and the siphunculus or tube placed along the back of the shell, whereas in the Nautilus it is central. The sides of the shell in the Ammonites are very generally more or less ornamented with arched elevations and depressions, and studded with spines and tubercles, as in the specimens above figured.

There are several kinds of Ammonites found in the Lias at Whitby and other places in Yorkshire; the most common species is figured in *Lign.* 7. p. 20; the dark colour of this fossil is produced by the argillaceous stone with which it is now filled. The internal structure of these Ammonites is generally well preserved, the chambers being lined with spar or other mineral matter; transverse polished sections are often very beautiful from the several cells being occupied by variously coloured marble, susceptible of a high polish. (Pl. III.) In some examples the entire shell is transmuted into brilliant pyrites (sulphuret of iron), and the chambers are filled with white spar; a specimen of this kind in my possession, collected by Lady Murchison, is the most elegant fossil imaginable.

Polished section of an Ammonite.

Page 70.

It is not unusual for the visitors at Whitby to inquire of the collectors how it is that the head of the animal is never found? and the crafty dealers, willing to accommodate the taste of their customers, carve the extremity of an Ammonite into the semblance of a serpent's head, and affix two red eyes; thus producing a veritable proof of the truth of the legend of St. Hilda! My young readers will not be duped by this trick-of-trade, if they reflect but a moment on the real nature of a fossil Ammonite: they will remember that it is a shell which, when empty, became filled with what was then soft mud, but is now stone; in like manner as if liquid plaster of Paris were poured into an empty snail-shell and consolidated.

In some parts of Somersetshire, a beautiful marble composed of an aggregation of two or three small species of Ammonites, is used for sideboards and other ornamental purposes: the polished slabs are diversified by the numerous sections of the shells.

Some of the clays of the Lias abound in a species of Ammonite of extraordinary beauty from the iridescent lustre of the pearly coat of the shell: a slab of stone from

Watchett, on which a hundred or more Ammonites of this kind are displayed, may be seen in the British Museum.

Note IV. Page 23. *Fossil Nautili.*

The beauty, elegant form, and remarkable internal structure of the shell of the Nautilus, have rendered it in all ages an object of curiosity and admiration: yet an accurate knowledge of the organization of the animal to which it belongs, has but recently been obtained. The Nautili may be regarded as Cuttle-fish or *Sepiæ*, inhabiting shells furnished with an apparatus to impart buoyancy, and enable the animals to swim on the surface, or sink to the profound depths of the ocean. A few explanatory remarks on the nature of the recent *Sepiæ* may be necessary to render the subject intelligible to the unscientific reader.

The *Sepia* or Cuttle-fish of our seas is of an oblong form, and composed of a soft substance covered with a tough integument or skin: it varies from a few inches to a foot or more in length. The mouth is placed in the

centre of one extremity of the body, and has a pair of powerful, curved, horny mandibles, much resembling the beaks of a parrot: it is surrounded by eight long arms like the rays of a star-fish, and these are beset with rows of little cups which act as suckers, and enable the animal to secure its prey, and attach itself with great firmness to any object.* It has a distinct head, with two eyes as perfect as in the vertebrated animals, and complicated organs of hearing: and below the head there is a tube or funnel which acts as a locomotive instrument, and propels the animal backwards by the forcible ejection of the water which has served the purpose of respiration, and can be thrown out with considerable force by the contraction of the body. The soft parts are supported by a large internal bone or osselet of a very curious structure, which, when dried and reduced to powder, forms the substance used by scriveners, termed *pounce*. These naked mollusca also possess a membranous bag or sac, containing a dark-

* From this arrangement of the organs of prehension around the head, this order of mollusca is termed the *Cephalopoda; i. e.*, the feet around the head.

coloured fluid resembling ink in appearance, which they eject into the surrounding water upon the approach of danger, and by the obscurity thus induced foil the pursuit of their enemies. This fluid, when inspissated, forms the base of the colour termed *sepia* by artists.

The body of the Nautilus resembles in its essential characters that of the Cuttle-fish, and occupies the large outer receptacle of the shell; maintaining a connection with the inner compartments by means of the membranous siphunculus or tube, which is only partially invested with shell. The internal chambers are air-cells, and the animal can fill the siphunculus with fluid, or exhaust it at will; the difference thus effected in its specific gravity enables it to rise to the surface or sink to the bottom with facility. Now if we imagine a Cuttle-fish placed in the outer chamber of a Nautilus-shell, and provided with a siphuncule, but having neither ink-bag nor osselet—these organs being unnecessary to an animal possessing a chambered shell—we shall have a general idea of the nature of the recent species.

The Nautilus is essentially an inhabitant of deep water:

it creeps along the ground at the bottom of the sea, with its shell upwards like the snail; and by means of its arms can proceed with considerable speed.*

A large and splendid species of fossil Nautilus is not uncommon in the London Clay of the Isle of Sheppey, Sussex, and Hampshire. The chambers are often lined with spar or other brilliant mineral matter; and polished sections, like those of the Ammonites, admirably display the internal structure.†

Note V. Page 27. *Brighton Cliffs.*

The stranger who approaches Brighton by the railroads through deep tunnels and cuttings in the chalk, and perceives the town spread over the plain and on the sides of a valley of the South Downs, will naturally expect to find the sea-shore bounded by chalk-cliffs. But a wall of

* See '*Conchologia Systematica*,' vol. ii. p. 302, and '*Elements of Conchology*,' p. 22, by Mr. Lovell Reeve, F.L.S., for an admirable description of the recent Nautilus, with illustrations.

† See Dr. Buckland's '*Bridgewater Treatise*' for numerous figures of Ammonites and Nautili; *plates* 31 to 34. Consult also '*Medals of Creation*,' vol. ii. p. 457.

admirable construction, extends from the Steyne to beyond Kemptown, and effectually conceals from view the materials that compose the site of that part of Brighton; a ramble along the shore to Rottingdean is therefore necessary to reveal to the inquiring observer, the nature of the strata that flank the southern border of the Downs.

The sketch given in page 27, represents the appearance of part of the coast to the east of Kemptown. The base of the cliff to the height of a few feet, is seen to consist of the white chalk with its usual layers of flint nodules, forming a low wall or terrace, which slopes seaward, and extends far into the British channel—probably to the opposite coast of France: at low-water a considerable expanse of modern shingle and sand is spread over, and in a great measure conceals, the chalk, at a few yards distance from the cliff. Upon the terrace of chalk, at the height of from ten to fifteen feet above the modern beach, there is a bed of pebbles and sand, containing also a considerable number of boulders of granite, porphyry, and other crystalline rocks foreign to the south-east of England: in fact, a sea-beach, which

must have been formed at some remote period, in the same manner as the modern shingle. Upon this ancient beach are strata of loam, and chalk-rubble, with flints partially water-worn, and boulders of sandstone, breccia, granite, &c., constituting the upper sixty or eighty feet of the cliff. In these beds, and also in the ancient shingle, many teeth and bones of mammoths (extinct species of elephant), horse, deer, oxen, and other ruminants, and bones of whales, have been discovered.*

A few hundred yards beyond Kemptown the inroads of the sea have destroyed all vestiges of the strata above described, and the cliffs consist of a perpendicular wall of chalk; if we extend our walk to Rottingdean, we shall perceive here and there isolated patches of the ancient shingle, and of the calcareous strata containing elephants' bones.

The appearances described demonstrate the following changes in this part of the Sussex coast. *Firstly*, the chalk terrace (*Lign.* 9, *c*; p. 27) on which the ancient shingle (*b*) rests, was on a level with the sea for a long period; for this beach must have been accumulated, like

* See '*Medals of Creation*,' p. 914.

the modern, by the action of the waves on the then existing chalk cliffs. But there must also have been some cause not now in operation, by which pebbles, and boulders of granite and other rocks foreign to this coast, with bones of extinct mammalia, &c., were thrown up on the strand, and imbedded in the beach then in progress of formation. These materials were probably brought from some distant part of the then continental shores by floating ice: an agency by which delicate bones and shells may be transported and deposited without injury amidst pebbles and boulders.

Secondly. The whole line of coast with the ancient shingle must have subsided to such a depth as to admit of the deposition of the calcareous materials forming the "*Elephant bed;*" and from the absence of beach and shingle in these strata, it may be inferred that this deposition took place in tranquil water: possibly at that period this part of the Sussex coast formed a sheltered bay.

Lastly. The land was elevated to its present level, and the formation of the modern sea-beach and cliffs commenced.*

* See '*Medals of Creation*,' "On the Geological structure of Brighton Cliffs," p. 913.

Note VI. Page 38. *Rotaliæ in Chalk and Flint.*

The shells called *Rotaliæ* (see *Lign.* 5 and 6, p. 14 and 16) belong to a group of marine animals of very simple organization, and which present great variety in the form and markings of their testaceous coverings; but they all agree in having the sides of the shell pierced by numerous holes or foramina; whence the scientific term of the Order, *Foraminifera,* is derived: these openings are for the egress of delicate filaments, which appear to be organs of progression and respiration.

The *Foraminifera* are, with but few exceptions, exceedingly minute; in an ounce of sea-sand, between three and four millions have been detected. The body of these animalcules consists of uniform granules enclosed in a skin or integument, having one or more digestive sacs or cavities; these creatures appear, in fact, to be mere polypes, protected by testaceous coverings. Some have but a single cell; others have many, disposed in a conical or cylindrical form; many kinds, of which the *Rotaliæ* are

examples, are discoidal involutes, and divided internally by septa into distinct chambers:* they resemble in this respect the shell of the Nautilus, but are readily distinguished by the perforations.

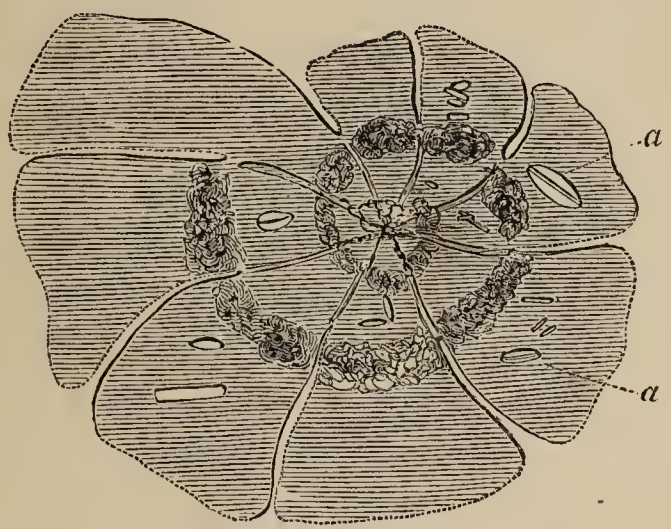
All the various kinds of *Foraminifera* swarm in the present seas, and were not less numerous in the ancient ocean. We have seen that the white chalk almost wholly consists of a few genera of these animalcules; and in many strata of sand they are so abundant, that a cubic inch of the mass contains upwards of sixty thousand. In the *Rotalia*, the body is entirely enclosed within the shell, and occupies all the cells; and long, soft, tentacula are sent off through the foramina. The shell, therefore, though resembling in form that of the Nautilus, is essentially different; for in the latter, the outer chamber only is occupied by the body of the animal, the internal ones being successively quitted empty dwellings; whereas, in the *Rotaliæ* and analogous *Polythalamia*,† all the cells

* See '*Wonders of Geology*,' 6th Edit. p. 322.

† *Polythalamia, many-chambered*, is a general term applied to these shells.

are contemporaneously filled by the soft parts of the animalcule.

When the shell is removed, which is readily effected by immersion in diluted hydrochloric acid, the body is exposed,



LIGN. 23:—The body of a recent animalcule allied to the *Rotalia*, deprived of its shell; *highly magnified.*

and found to consist of a series of lobes or sacs, united by a tube corresponding somewhat in its position with the siphuncle of the Nautilus, but which is the digestive canal. The body of a recent animalcule of this kind, deprived of the shell, is figured in *Lign.* 23.

Not only the characters of fossil shells of such infinite minuteness can be revealed by the microscope, but even the soft parts of the animalcules which inhabited them; for these are occasionally preserved, and may be demonstrated with as much distinctness as the recent examples.* In flint the soft parts of *Rotaliæ, Textulariæ,* &c., are abundant, and may be seen, with but little preparation, like insects in amber: the specimen figured in *Lign.* 12, p. 39, shews the body of a *Rotalia* well defined; the only preparation this atom of flint has undergone, is immersion in Canada balsam. To detect such delicate structures in chalk requires, however, some experience in microscopic manipulation, as the calcareous matter must be dissolved in hydrochloric acid, and the animal substance separated from the residuum.†

Note VII. Page 43. *Isle of Wight Pebbles.*

The nodules and veins of flint that are so abundant in

* See '*Wonders of Geology*,' 6th Edit., p. 322.

† See my '*Memoir on the fossil remains of the soft parts of Foraminifera in Chalk, &c.*,' Philosophical Transactions, 1846, p. 465.

the upper chalk, have probably been produced by the agency of heated waters and vapours; the perfect fluidity of the siliceous matter before its consolidation is proved, not only by the sharp moulds and impressions of shells and other organisms retained by the flints, but also by the presence of numerous remains in the substance of the nodules, and the silicified condition of the sponges and other zoophytes which abound in the cretaceous strata.

Now although silex, or the earth of flint, is but sparingly soluble in water of the ordinary temperature, its solution readily takes places in vapour heated a little above that of fused cast iron, as has been proved by direct experiment;* and similar effects are being produced at the present moment by natural causes. The siliceous deposits thrown down by the intermittent boiling fountains, called the Geysers, in Iceland, are well known;† and in New Zealand this phenomenon is exhibited on a still grander scale. From the crater of the volcanic mountain of Tongariro,‡ which is several thousand feet above the level of the sea,

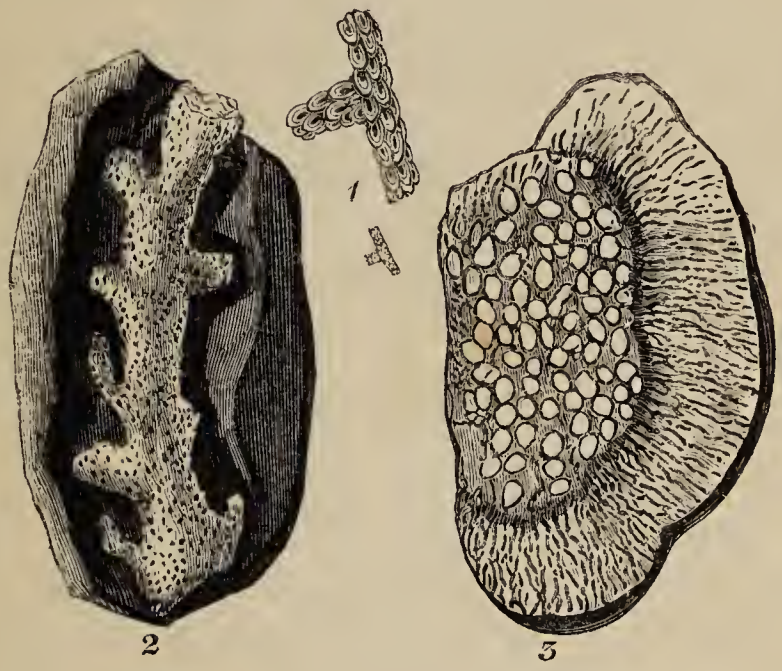
* See '*Wonders of Geology*,' p. 100.

† Ibid., p. 95. ‡ Ibid., p. 98.

jets of vapour and streams of boiling water highly charged with silex, are continually issuing forth, and dashing down the flanks of the volcano in cascades and torrents, empty themselves into the lakes at its base. As the water cools, siliceous sinter is deposited in vast sheets, and incrustations of flint form around the extraneous substances lying in the course of the thermal streams. Silex is also precipitated by the boiling waters in stalagmitic concretions, and in nodules resembling in colour and solidity the flints of the English chalk. The complete impregnation and silicification of organized bodies is attributable to an agency of this kind; and although the origin of the siliceous waters that deposited the nodules and veins of flint in the chalk is still involved in obscurity, the mode in which the latter were formed is satisfactorily elucidated.

Of the perfect transmutation into flint of the most delicate organic structures, the pebbles strewn along the sea-shore of the south coast of England, afford a beautiful illustration; those from the Isle of Wight are especially celebrated for their rich and varied colours. The most common and interesting are those which exhibit sections of Choanites,

as in the specimen which suggested the reflections embodied in these pages. Other allied forms are scarcely less beautiful; the petrified zoophytes called *Siphonia*,



LIGN. 24.—Zoophytes in Chalk and Flint.

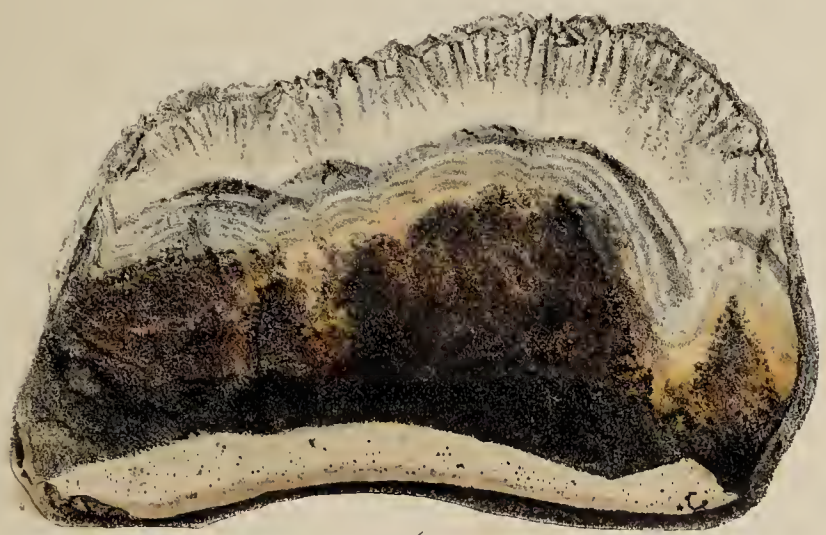
1. A minute coral from chalk and flint; the lower figure is of the natural size.
2. Branch of a sponge in flint. 3. Pebble enclosing a zoophyte.

which, when living, consisted of a soft mass traversed by tubes, for the free ingress and egress of the water, often display the internal structure of the original:

as in the polished transverse section figured above, *Lign.* 24, *fig.* 3. Other bodies of this class occur in the flint, and present interesting examples of the zoophytes of the chalk ocean.

But many of the Isle of Wight pebbles exhibit no traces of animal structure, yet are valuable and instructive as mineralogical specimens: such are the clear and transparent pebbles with bands and veins of quartz and chalcedony. Some specimens are as pellucid as rock-crystal; others are of a bright yellow, amber, dark-brown, and bluish-black colour, and are often mottled with dendritical or arborescent manganese. (Plate iv.) The moss agates, as they are called by the lapidaries, are silicified sponges. Small pebbles of pure transparent rock-crystal are often found among the shingle in Compton and Sandown bays, and have probably been washed out of the wealden strata; for similar stones occur in the Tilgate grit, and at Tunbridge Wells: in the latter place, they are cut and polished for rings, brooches, &c.

On the shores of the Isle of Wight, pebbles of jasper, resembling those from Egypt, and of banded quartz, with



1.

2

Polished sections of Pebbles.

Page 86.

arborescent markings, or with zones of rich brown, are also met with; these do not appear to have originated from the chalk strata.

Pebbles of silicified wood have been collected in Sandown bay by Mr. Fowlstone; and water-worn boulders and pebbles of petrified wood, bones, &c., are common in Brook bay; rolled masses of the fresh-water shelly limestones (Sussex and Purbeck marbles) are also abundant in the same localities.*

Note VIII. Page 45. *Zoophytes of the Chalk.*

Zoophytes, especially sponges, occur in such prodigious numbers in some of the chalk strata, that the nucleus of almost every flint nodule is an organic body. In many instances the silex has completely permeated the animal substance, as in the pebbles before described; but sometimes the sponge is a white calcareous mass, occupying a hollow in the flint: a branched specimen of this kind,

* All these varieties may be obtained of Mr. Fowlstone, 4, Victoria Arcade, Ryde.

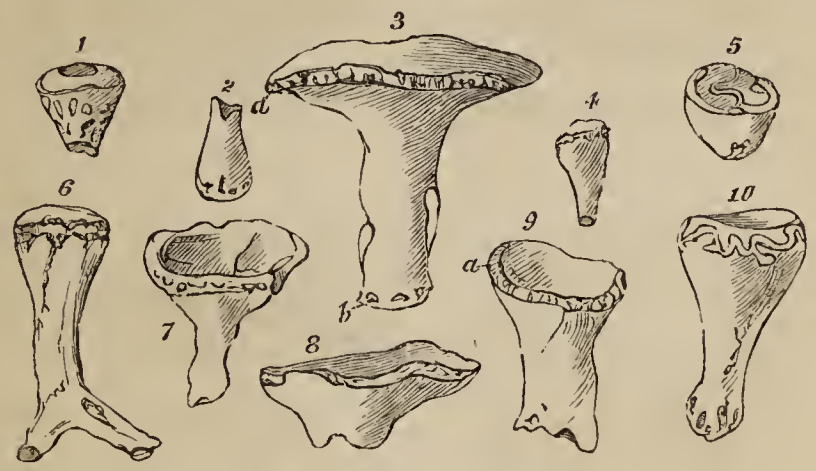
exposed on breaking a small nodule, is represented at *Lign.* 24, *fig.* 2.

In describing sponge as an animal substance, it may be necessary to explain that the sponge in ordinary use is the flexible skeleton of a living zoophyte, and was originally invested with a gelatinous or slimy matter, which lined all the pores and channels. When alive in the water, currents constantly enter the outer pores, traverse all the internal inosculating canals, and issue from the larger orifices which often project above the surface in perforated papillæ. By the circulation of the sea-water through the porous structure, the nutrition of the animated mass is effected; and the modifications observable in the number, size, form, and arrangement of the pores, canals, and apertures, in the different kinds of this type of organization, are subservient to this especial function.

But associated with the true *Poriferæ* or sponges, are numerous zoophytes which resemble them in form, but are of an entirely distinct nature; for they are the fossilized remains of *Polyparia,* that is, of the frame-work of an aggregation of polypes, each individual of which had

an independent existence, although the whole were united by one common living integument, like the *Alcyonium*, or dead-men's fingers, of our coasts.*

Among the flints whose forms depend on the organic bodies they enclose, are some which bear so close a resemblance in shape to *Fungi*, that they are provincially called

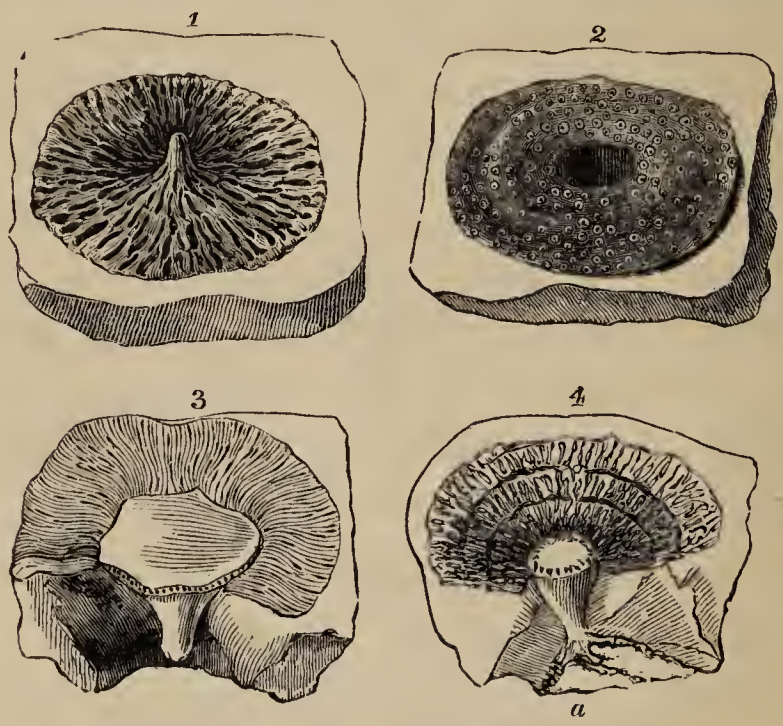


LIGN. 25.—Flints deriving their forms from the zoophytes they enclose.

in Sussex "*petrified mushrooms;*" several of them are figured above (*Lign.* 25). In these fossils there are openings at the base, and a groove on the margin of the upper part, in which the structure of the enclosed body is gene-

* See '*Medals of Creation*,' p. 251.

rally more or less distinctly seen; and upon breaking one of these bodies, a section of a funnel-shaped zoophyte is obtained. The origin of these flints will be understood



LIGN. 26.—Ventriculites from the Chalk, Lewes.

1. A perfect specimen in Chalk, shewing the external net-like surface.
2. An expanded specimen, displaying the inner surface studded with cells.
3. A Ventriculite with the lower part enveloped in Flint.
4. Part of a Ventriculite; the base invested with Flint: the root-like fibres are seen at *a*.

by reference to the four interesting specimens here delineated, one-sixth of the natural size in linear dimensions.

This zoophyte, to which the name of *Ventriculite* has been given to denote its usual shape, was a hollow inverted cone, terminating at the base in a point, whence radicles or root-like processes were sent off, by which the animal was firmly attached to the rock. The outer integument was disposed in meshes like a net (see *Lign.* 26, *fig.* 1), and the inner surface was beset with regular circular openings, the orifices of tubular cells (*fig.* 2); each of which was probably occupied by a polype. The substance of the *Polyparium,* or general support of this family of animalcules, which alone occurs in a fossil state, appears to have been analogous to that of the soft *Alcyonia,* and to have possessed a common irritability; the entire mass contracting and expanding, as is the case in many recent zoophytes.*

The flints, *figs.* 3, 7, 8, 9, *Lign.* 25, were evidently formed in the manner exemplified in *fig.* 3, *Lign.* 26; *figs.* 2, 4, 6, are illustrated by *fig.* 4, *Lign.* 26; for the chalk

* See '*Wonders of Geology,*' 6th Ed., p. 610; '*Medals of Creation,*' p. 273–276; and '*Geological Excursions round the Isle of Wight,*' pp. 179–184, for an account of the silicification of these and other Zoophytes.

specimens, *Lign.* 26, shew that all these flints have been moulded around *Ventriculites*, and that their diversity of figure has arisen from the quantity of silex that happened to permeate the substance of the zoophyte; if but a small portion, flint like figs. 2 and 4, were the result; if the quantity were considerable, the larger fungiform examples were produced.

Note IX. Page 50. *Minute Corals from Chalk.*

Some layers of chalk are composed of an aggregation of many kinds of delicate corals, the interstices being filled up with *Rotaliæ* and other foraminiferous shells. In the cliffs near Dover there are several beds of this nature, well known to collectors for the profusion of exquisite specimens they yield to the experienced investigator. *Lign.* 17, p. 50, represents several varieties from different localities; the small figures shew the natural size, and the enlarged ones their appearance when magnified. Attached to the surface of shells, and sometimes standing erect in crannies of flint nodules, beautiful corals may often be

detected by the aid of a lens of moderate power. By brushing chalk in water, and examining the deposit, delicate fossils of this kind may also be obtained.*

From the close analogy of the fossil corals to existing forms, it would not be difficult to give restored figures of the originals. Every little branch might be represented fraught with living polypes: in some cells the agile inmates might be shown with the mouth expanded, and the tentacula in rapid motion; in others withdrawn into their stony recesses, and devouring the infinitesimal atoms that constitute their food: even their varied hues might be introduced, and thus a vivid picture be presented of the microscopic beings which peopled the waters of the ancient chalk ocean.

That the Corals, which from their elegance and beauty are preserved in almost every cabinet, have been fabricated—or, in other words, built up—by polypes, in the same manner as the honey-comb of the bee and wasp, is so prevalent yet erroneous an opinion, that I am induced

* Refer to '*Medals of Creation*,' p. 284, and to '*Wonders of Geology*,' *Lecture VI.* p. 588, for a comprehensive view of Recent and Fossil Corals.

to point out its fallacy, by giving a brief account of the formation of these substances. The three recent specimens represented in *Lign.* 27 will serve to illustrate my remarks.

1 2 3

LIGN. 27 :—Recent Corals.

1. *Oculina ramea.*
2. *Madrepora muricata.*
3. *Isis hippuris.*

The coral, *fig.* 1, was an internal axis or skeleton, deposited by the soft fleshy integument with which, when living, it was wholly invested; in the same manner as are the bones of animals, by the special membrane *(perios-*

teum) that secretes them. This integument lined every cell, and the polypes were permanently united to it. When the live coral is taken out of the water, the animalcules shrink up and quickly perish; their soft parts and the external investing substance putrefy, and the stony axis beset with the radiated cells alone remains.

In the example of *Oculina ramea,* or May-blossom Coral, *fig.* 1, from the Mediterranean, the cells are large and distinct; in the *Madrepore* from the West Indies, *fig.* 2, they are small and very closely aggregated.

The specimen of *Isis* (*fig.* 3,) belongs to a group of coral-zoophytes in which the polype-cells consist of a substance that is durable, but not so hard as coral, and invests an axis composed of a tough flexible material, which is exposed at the base of *fig* 3, by the removal of the external or cortical part in which the polypes were situated. The *Gorgonia,* or Venus's fan, has a similar structure and composition.*

In the *Red Coral,* so largely employed in the manufacture of beads, brooches, and other ornaments, not only

* See '*Wonders of Geology,*' vol. ii. p. 616.

the animalcules, but also their receptacles, are composed of a soft perishable substance. When alive, the polypes, as well as the investing fleshy integument, are of a delicate bluish tint; the internal calcareous axis alone possesses the peculiar red colour. Upon being taken out of the sea, vitality quickly ceases, the soft parts decompose, and the beautiful crimson stone commonly known as the *true coral*, is obtained free from all traces of the soft mass by which it was secreted. Although an actual investigation of the facts described can only be instituted near the seas of warm climates, yet our coasts abound in certain coral-zoophytes in which similar phenomena may readily be observed. Most persons in their rambles by the sea-side must have noticed on the fuci, algæ, shells, pebbles, &c., patches of a white earthy substance, which when closely examined resemble delicate lace-work. These apparently calcareous incrustations are clusters of the zoophytes termed the *Flustra*, or sea-mat.* When removed from the water, this aggregation of polypes seems coated over with a glossy film or varnish; and with a

* See '*Wonders of Geology*,' Plate 5.

lens of moderate power the surface is seen to be full of pores, disposed with much regularity. If viewed under the microscope while immersed in sea-water, a very different appearance is presented. Every pore is found to be the opening of a cell whence issues a tube fringed with several long feelers or arms; these expand, then suddenly contract and withdraw into the cell, and again issue forth; the whole surface of the Flustra being covered with these hydra-like animalcules. The Flustra, therefore, like the corals, constitutes an assemblage of polypes, each individual being permanently fixed in a durable cell, and the whole attached to a common integument by which the calcareous frame-work was secreted and maintained.*

Note X. Page 53. *Infusorial earth from Richmond in Virginia.*

The greatest natural operations are produced by the most simple and apparently inadequate agents: for as the

* See Dr. Johnson's beautiful work on '*British Zoophytes*,' in which are numerous figures of various species of Flustra.

illustrious Galileo emphatically remarked, "*La nature fait beaucoup avec peu, et ses opérations sont toutes également merveilleuses.*" The profound thinker Hobbes, in the same spirit observes, "The majesty of God appeareth no less in small things than in great, and as it exceedeth human sense in the immensity of the universe, so also doth it in the smallness of the parts thereof." This sublime truth is strongly impressed on the mind of the geological inquirer, who perceives that whole countries and mountain ranges of great elevation and extent, are wholly composed of the aggregated remains of beings of such infinite minuteness that but for the powerful optical instruments of modern times, their presence would never have been suspected.

A few years only have elapsed since the sagacious Ehrenberg first drew attention to this subject, and pointed out the proper method of investigation;* and so rapid has been the progress of discovery in this department of science, that *infusorial deposits*, as these beds of

* See '*Medals of Creation*,' p. 244, for instructions for the microscopical examination of earths, chalk, &c.

fossil animalcules are designated, have been detected in every quarter of the globe. A fact equally unexpected and remarkable has also been established, namely, that at the present moment similar minute living agents are largely contributing to the increase of the solid materials of the crust of our planet.

The infusorial earth of Virginia, alluded to in the text, is a yellowish siliceous clay, forming a deposit from twelve to fifteen feet in thickness, upon which the towns of Richmond and Petersburgh are built. The surface of the country over which it extends is characterized by a scanty vegetation, owing to the siliceous nature of the soil dependent on the minute organisms of which it almost entirely consists. When a few grains of this earth are properly prepared for microscopic examination, immense numbers of the shields or cases of animalcules are visible under a magnifying power of 300 diameters; in fact, the merest stain left by the evaporation of water in which some of the marl has been mixed, teems with these fossil remains.*

* Specimens of Infusorial earths, prepared for the microscope, may

These organisms are of exquisite structure, and comprise many species and genera. The most beautiful and abundant are the circular shields, termed *Coscinodisci* (sieve-like disks), which are elegant saucer-shaped cases, elaborately ornamented with hexagonal apertures disposed in curves, somewhat resembling the engine-turned sculpturing of a watch; these shells are from $\frac{1}{1000}$ to $\frac{1}{100}$ of an inch in diameter. A segment of one of these disks, highly magnified, is represented in *Lign.* 18, *fig.* 2. The body of the living animalcule was protected and enclosed by a pair of these concave shells, the perforations admitting of the exsertion of filaments or tentacula. This species of *Coscinodiscus* abounds in the present seas, and constitutes no inconsiderable proportion of the food of Pectens and other testaceous mollusca.*

All the animalcules found in the Richmond earth are marine, and most of them belong to genera, and many to

be obtained of Mr. Topping, 4, New Winchester Street, Pentonville Hill, New Road, London.

* See '*Thoughts on Animalcules*,' p. 103.

existing species; although the position of the American strata proves that they are referable to a period of immense antiquity.

In Germany, beds of a white infusorial earth, resembling magnesia in appearance, and termed *Bergh-mehl*, or fossil farina, occur at Bilin, and several other places: at San Fiora in Tuscany, near Egra in Bohemia, in the Bermudas, Barbadoes, &c., similar deposits have been discovered; all being composed of the shields of various kinds of animalcules. But I must not extend these remarks, and will only add a few observations on the infusorial earth of Barbadoes, which has but recently been brought under the notice of geologists by Sir Robert Schomburgk, and is especially interesting for the exquisite beauty and variety of its organisms, and the circumstances under which the deposit occurs.

Barbadoes, an island of the West Indies, is about twelve miles in length from north to south, and consists of coral reefs, capped in one district by tertiary sandstones and limestones, which attain a height of 1200 feet above the sea. Over the rest of the island, coral reefs

form the entire surface, which is divided by vertical walls of coral, some of them nearly 200 feet high, into six terraces, indicating as many periods of upheaval. In the lowest reef, Indian hatchets have been found twenty feet above high water mark; shewing that the last movement, at least, took place within the human period. The tertiary strata are more or less inclined, and in many places vertical, and contorted. Strata of marl, several hundred feet thick, predominate; and there are beds of bituminous coal, sandstone, clays, and ferruginous sands. Arenaceous limestone containing teeth of sharks, spines of echini, and shells, forms the summit of a hill nearly 1,000 feet high. The white marls abound in 300 species of the most beautiful siliceous infusoria; many are peculiar, others the same as occur in the Richmond earth, and some belong to recent species.*

* Sir R. H. Schomburgk: Brit. Assoc. 1847.

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